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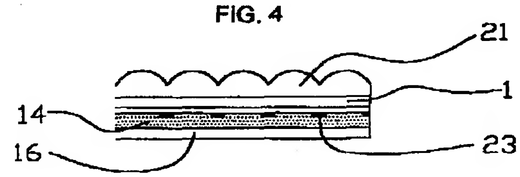
(54) Lenticular sheet, rear-projection screen or television using the same, and fabrication method for said lenticular sheet

(57) The present invention provides a lenticular sheet in which cylindrical lens parts consisting of a radiation curable resin are formed on one side of a transparent support, and at least a light-diffusing layer and light-blocking stripes are formed on the flat surface located on the opposite side of said sheet. Cylindrical lens parts with a fine pitch of 0.3 mm or less can be obtained; furthermore, finely pitched light-blocking stripes can be accurately formed in the desired positions.

A projection screen constructed by combining the aforementioned lenticular sheet with a Fresnel lens sheet is ideally suited for viewing a liquid crystal projection TV with a high image definition.

FIG. 4



EP 0 770 902 A1

Description

The present invention concerns a lenticular sheet which is suitable for use in the construction of a rear-projection screen (used in liquid crystal projection Television (hereinafter referred to as "TV") sets) in combination with a Fresnel lens sheet.

In particular, the present invention concerns a lenticular sheet [a] which has a simple construction in which lens parts are formed on one side only, [b] in which lens parts consisting of convex cylindrical lenses formed side by side can be formed at a fine pitch, and [c] in which a stripe-form light-blocking pattern (black stripe; hereinafter referred to as "BS") formed in positions corresponding to the non-focusing parts of the respective cylindrical lenses can be accurately formed in the desired positions.

Rear-projection screens generally consist of a combination of a Fresnel lens sheet and a lenticular sheet.

This lenticular sheet is generally constructed as follows: specifically, as is shown in Figure 1, convex cylindrical lens surfaces are formed on both sides of the sheet, and projections are formed in the boundary areas between respective cylindrical lenses on one side of the sheet (i.e., the side from which projected light is emitted), with light-blocking layers (light-absorbing black stripes) being formed on the upper portions of said projections.

The reason that convex cylindrical lens surfaces are formed on both the front and back sides is that in cases where the projector is a three-tube CRT type projector, it is necessary to correct the aberration for three colors (R, G and B) with the lenses on the incident side.

In recent years, liquid crystal projection TVs have become popular, and there has been a demand for rear-projection screens in order to view the projected images of such TVs.

Liquid crystal projection TVs are constructed as shown in Figure 2. Projected image light from a projector is projected onto a rear-projection screen via mirrors, and the observer views the projected image through said screen.

With increased definition of the projected image, the number of pixels in liquid crystal projectors has increased from the conventional number of several tens of thousands of pixels to a number exceeding one million pixels. As a result, there has been a demand for a finer pitch of the cylindrical lenses in lenticular sheets as well. As a result of this finer pitch, the moire phenomenon arising from the periodicity of the pixels of the liquid crystal projector and the periodicity of the cylindrical lenses is reduced.

In concrete terms, there is a need to reduce the pitch of current lenticular sheets, in which the cylindrical lenses are arranged at a pitch of around 0.7 mm, to a value of 0.3 mm or less.

Currently, lenticular sheets are obtained by subjecting a transparent thermoplastic resin sheet to press molding, or by molding both sides of the sheet at the same time that the sheet is formed by melt extrusion. However, in the case of various methods used for the molding of thermoplastic resins, it is extremely difficult to obtain the abovementioned fine pitch. The reason for this is that a nonuniform temperature distribution is generated during cooling following the hot molding process, so that heat recovery phenomena characteristic of plastics occur: i.e., warping of the molded sheet may occur, or nonuniform heat shrinkage may take place.

Various molding methods using ultraviolet or electron beam curable resins are known as desirable fabrication methods for molding lens sheets with a fine pitch. In particular, the following proposals have been disclosed:

The Japanese Patent Publication No. 61-177215 discloses a Fresnel lens and method for fabricating the same, wherein the Fresnel lens is equipped with a transparent resin plate and an ultraviolet curable resin which is bonded to said transparent resin plate by polymerization, and which has Fresnel lens surfaces on the opposite side of said resin from said transparent resin plate, said lens being formed by pouring an ultraviolet curable resin into the space between a Fresnel lens mold and the aforementioned transparent resin plate.

Moreover, the Japanese Patent Publication No. 63-134227 discloses a method, wherein a Fresnel lens mold is coated with an ultraviolet or electron beam curable resin, after which a film is laminated with said resin while defoaming is performed, and molding is performed by irridiation with ultraviolet light or an electron beam. Next, the film and resin are removed from the mold and integrated with a transparent substrate.

The object of almost all molding methods using ultraviolet or electron beam curable resins, as represented by the proposals described above, is the manufacture of Fresnel lens sheets, which have a relatively complicated shape compared to lenticular sheets. However, there have been no proposals concerning the fabrication of lenticular sheets for use in rear-projection screens.

Furthermore, in cases where lenticular sheets molded by various methods are used as screens, BS patterns have conventionally been formed in order to improve the contrast.

Various types of printing methods such as offset, gravure or screen printing, etc., have customarily been used as methods for forming BS patterns. In the case of printing methods, however, printing plates which have a high positional precision wherein the image line parts are light-absorbing parts must be prepared. Accordingly, in cases where the pitch of the cylindrical lenses is reduced, or the size of the lenticular sheet is increased, the preparation of printing plates and the alignment of said plates during printing become much more difficult.

The method described below is known as an example of a method other than an ordinary printing method for forming light-blocking patterns.

The Japanese Patent Publication No. 59-121033

discloses a method which allows a rear-projection screen on which a BS pattern with superior light-blocking properties is formed to be obtained easily and inexpensively, and without any need for a wet process, as follows: specifically, a positive type photosensitive adhesive agent, i.e., an adhesive agent which loses its adhesive properties when exposed to light, is installed on the viewing side of a rear-projection screen (lens sheet), and this adhesive agent is exposed from the opposite side of the screen from said adhesive agent by light projected from a projection light source projector or a light source which has an equivalent aperture, so that the adhesive properties of the focusing portions of the respective unit lenses of the lens sheet are eliminated, after which a light-blocking toner is applied from the viewing side, and is caused to adhere to the unexposed portions which retain adhesive properties. Afterward, the excess toner and the toner adhering to the aforementioned portions which have lost their adhesive properties as a result of exposure are removed.

In particular, the method as disclosed in this prior art document allows a BS pattern to be accurately formed in positions corresponding to non-focusing parts even in the case of a lenticular sheet which has finely pitched cylindrical lenses.

The present invention concerns a lenticular sheet which is used in combination with a Fresnel lens sheet to form a screen used in a liquid crystal projection TV, said lenticular sheet being characterized by the fact that said sheet has a simple structure in which lens parts are formed on one side only, with a BS pattern being formed on the flat surface of the other side of said sheet.

Specifically, the object of the present invention is to provide a lenticular sheet which has finely pitched lens parts that are suitable for the viewing of a high-definition, high-image-quality liquid crystal projection TV, and in which an even more finely pitched BS pattern corresponding to said lens parts is accurately formed in desired positions, and a method for fabricating said lenticular sheet.

According to the present invention, the above objects are achieved by a lenticular sheet comprising a transparent support, a lens portion comprising convex cylindrical lenses made of a cured radiation curable resin which are disposed side by side on one side of said transparent support, a stripe-form light-blocking pattern disposed in positions corresponding to the non-focusing parts of the respective cylindrical lenses on the flat surface, which is located on the side of said support opposite to said lens portion, and a light-diffusing layer on top of said stripe-form light-blocking pattern.

Moreover, the above objects are achieved by a lenticular sheet comprising a transparent support, a lens portion comprising convex cylindrical lenses made of a cured radiation curable resin which are diposed side by side on one side of a transparent support, a light diffusing layer over the entire flat surface, which is located on the side of said support opposite to said lens portion, and a stripe-form light-blocking pattern disposed in positions corresponding to the non-focusing parts of the respective cylindrical lenses on top of said light-diffusing layer.

Moreover, the above objects are achieved by a method of fabricating the lenticular sheet as defined above, comprising the steps of applying a radiation curable resin, in which a powdered inorganic compound has been dispersed and mixed as a coating to the flat surface of said transparent support having said lens portion formed on one side and having a flat surface on the opposite side, curing said radiation curable resin by irradiation with radiation from the cylindrical lens side so that said radiation is focussed by said cylindrical lenses, imparting a black color to the areas of the surface other than the cured areas.

Furthermore, the above objects are achieved by a rear-projection screen comprising the lenticular sheet as defined above and a Fresnel lens sheet, as well as by a rear-projection TV comprising this rear-projection screen.

Figure 1 is an explanatory diagram which illustrates a conventional lenticular sheet.

Figure 2 is an explanatory diagram which schematically illustrates the structure of a liquid crystal projection TV.

Figure 3 is an explanatory diagram which illustrates one example of a lenticular sheet fabricating device.

Figure 4 is a sectional explanatory diagram which illustrates one example of the lenticular sheet of the present invention.

Figure 5 is a sectional explanatory diagram which illustrates another example of the lenticular sheet of the present invention.

Figure 6 is a sectional explanatory diagram which illustrates another example of the lenticular sheet of the present invention.

Figure 7 is an explanatory diagram which shows how the location of BS formation differs for each cylindrical lens in a case where exposure by means of divergent light is used to form the BS pattern on the flat surface of the lenticular sheet.

Figure 8 is an explanatory diagram which illustrates one example of the exposure device used for exposure formation of the BS pattern on the flat surface of the lenticular sheet.

Figure 9 is an explanatory diagram which illustrates the optical design of the lenticular sheet of the present invention.

Figure 10 is a graph which shows the relationship between the ratio of the thickness of the light-blocking pattern to the lens thickness (D'/D) and the aperture rate.

The present invention will be described with reference to the attached figures:

Figure 3 shows one example of a device which continuously fabricates the lenticular sheet of the present invention.

This fabricating device is equipped with a coating device 2 which coats a film-form transparent support 1

supplied from a roll with an ultraviolet curable resin (UV curable resin), a lens forming roll 3 which has the inverted shapes of lenticular lenses formed on its surface, a pressing roll 3', an ultraviolet irradiation device 4, and a pair of laminating rolls 5, 5' which laminate an ultraviolet-sensitive resin film 6, supplied from a roll, with the support film on which the aforementioned lenticular lenses have been formed. In Fig. 3, reference numerals 7 and 8 designate an exfoliation film and a protective film, respectively, of the ultraviolet-sensitive resin film 6. Said ultraviolet-sensitive resin film 6 is laminated on the opposite side of the support film from the aforementioned lenses. The fabrication device further comprises an ultraviolet irradiation device 9, a pair of laminating rolls 10, 10' which are used for forming a black transfer layer by means of a transfer sheet 11 supplied from a roll, a pair of laminating rolls 13, 13' which laminate a light-diffusing film 14 supplied from a roll, and a pair of laminating rolls 15, 15' which laminate a transparent resin film 16, supplied from a roll, that has an anti-electrification function or an anti-reflection function, etc. In Fig. 3, reference numeral 12 designates a support film of the transfer sheet 11.

The abovementioned fabricating device is ideal for the continuous fabrication of a lenticular sheet which uses a continuously supplied film as a support. However, the present invention is not limited to such a device; it would also be possible to accomplish lens formation using a stamper instead of a roll, and an individual sheet type fabricating device could also be used.

A lenticular sheet is manufactured as described below using the abovementioned fabricating device.

A transparent resin film with ultraviolet transmissivity is desirable for use as the transparent support 1, and it is even more desirable that said support be subjectd to a treatment which facilitates adhesion of a UV curable resin on the side of the support on which the aforementioned lens parts are formed. Materials which can be used for this support include polyethylene terephthalate (PET), polycarbonate (PC) or polyvinyl chloride (PVC), etc.

There are no particular restrictions on the coating device 2 used to apply the aforementioned UV curable resin; however, a coating device such as a doctor blade or die coater, etc., is desirable.

The thickness of the UV curable resin coating formed on one side of the transparent support 1 varies according to the shape of the lenticular lenses being formed; however, a coating thickness of 0.1 mm to 0.2 mm is appropriate. Furthermore, the coating thickness may be adjusted in accordance with the viscosity of the resin and the feeding rate of the support film, etc.

Next, the support film which has been coated with the aforementioned UV curable resin is passed between lenticular lens forming rolls 3, 3' so that the shape of the lens forming roll 3 is transferred to the UV curable resin; at the same time, the resin is cured by ultraviolet irradiation from the ultraviolet irradiation device 4, so that lens parts 21 (not shown in the figure) are formed.

By forming the lens parts 21 from the aforementioned cured UV curable resin, it is possible to form a stable lens shape over the entire sheet even in the case of a lenticular sheet with a fine pitch of 0.3 mm or less.

The lens forming roll 3 which has inverted lenticular lens shapes formed on its surface can be obtained, for example, by installing a metal mold worked by cutting, or a resin mold copied from such a metal mold by a prescribed method, on the surface of a roll.

Next, the support film on which the aforementioned lenticular lenses consisting of a UV curable resin have been formed is fed between a pair of laminating rolls 5, 5' so that an ultraviolet-sensitive resin film 6 fed from a roll is laminated with said support film on the opposite side of said support film from the aforementioned lenses.

As was mentioned above, the aforementioned Japanese Patent Application Kokai No. 59-121033 discloses a method which allows a BS pattern to be accurately formed in positions corresponding to non-focusing parts even in the case of a lenticular sheet which has finely pitched cylindrical lenses.

A BS pattern can be formed on the flat surface of the lenticular sheet by means of the abovementioned proposed method in the present invention as well.

A film with characteristics which are such that the ultraviolet-exposed portions react to become non-adhesive while the unexposed portions remain adhesive is desirable for use as the abovementioned ultraviolet-sensitive resin film 6.

For example, an ink foil sold under the trademark Cromalin, manufactured by Du Pont, may be used as the abovementioned ultraviolet-sensitive resin film; this film is passed between laminating rolls 5, 5' heated to 110°C, and is laminated with the support film on the opposite side of said support film from the aforementioned lenses. Then the exfoliation film 7 and the protective film 8 are peeled from the ultraviolet-sensitive film 6.

Next, non-adhesive parts and adhesive parts corresponding respectively to the focusing parts and non-focusing parts based on the focusing effect of the lenticular lenses are formed in the ultraviolet-sensitive resin film by irradiation with ultraviolet light from the ultraviolet irradiation device 9, and a black transfer layer is transferred only to the aforementioned adhesive parts from a transfer sheet 11, supplied from a roll, by passing the aforementioned film beween the aforementioned pair of laminating rolls 10, 10' after the protective film has been peeled away from the surface of said film, so that a BS pattern 23 (not shown in the figure) is formed. Then the support film 12 is peeled from the transfer sheet 11.

The abovementioned BS pattern is formed on the flat surface of the lenticular sheet which is located on the side of the observer. Accordingly, in order to form focusing parts in positions which are the same as in the case of actual screen use, it is necessary to perform the exposure process by means of parallel light over the entire surface of the lenticular sheet from the side of the

cylindrical lenses.

In cases where the lenticular sheet is irradiated with divergent light instead of parallel light, as is shown in Figure 7, there is a difference in the position of BS formation for the repective cylindrical lenses between the central portion of the lenticular sheet directly in front of the light source and the end portions of the lenticular sheet, due to a difference in the focusing position arising from the fact that the angle of incidence of the light source with respect to the cylindrical lenses is different.

In cases where a lenticular sheet with such as BS pattern is used as a rear-projection screen, a Fresnel lens sheet is present on the projection side; as a result, the following drawback arises: i.e., at the end portions of the screen, projected light strikes the BS so that there are missing portions in the projected image that is observed.

An exposure method of the type shown in Figure 8 is effective for ultraviolet irradiation.

Figure 8 is an explanatory diagram which illustrates a case in which the lenticular sheet is irradiated from the cylindrical lens side in a direction perpendicular to the flat surface of said lenticular sheet with band-form light extending in the direction of length of the cylindrical lenses, i.e., in the direction perpendicular to the plane of the paper in Figure 8, while the light source and the lenticular sheet are caused to move relative to each other in the direction in which the cylindrical lenses are lined up side by side.

One possible method for obtaining the abovementioned band-form light is to cause the light from the ultraviolet irradiation device 9 to pass through a slit 31 formed in a mask 30.

By using the abovementioned exposure method, it is possible to achieve the accurate formation of a BS pattern in uniform positions for all of the cylindrical lenses, even in the case of a lenticular sheet in which the cylindrical lenses are arranged at a fine pitch.

For example, an ink foil, sold under the trademark Cromalin, manufactured by Du Pont, etc., is used for the pressure transfer of the BS pattern 23; the line width of the BS pattern 23 can be adjusted in accordance with the amount of ultraviolet exposure and the feeding rate of the film.

Furthermore, as is shown in Figure 10, by controlling the thickness of the BS pattern so that the aperture rate is 90 % or greater (as indicated by the following equations, where P is the pitch of the convex cylindrical lenses, D is the thickness of the lenticular sheet, P' is the line width of the BS pattern and D' is the thickness of the BS pattern), it is possible to view the entire surface of the aperture through which the projected light passes without any blockage of the observational light path, not only from directly in front of the screen, but also in cases where the screen is viewed from a wide angle to the left or right. Thus, a screen which produces a bright image can be obtained.

$$\theta = \tan^{-1}\{(P - P')/2D\}$$

$$\theta = \tan^{-1}\{(P - P')/2(D + D')\}$$

$$\text{aperture rate} = (\theta - \theta')/\theta$$

The abovementioned aperture rate is the value obtained by subtracting the loss of transmitted light caused by the blockage of the projected light by the thickness of the BS pattern from 100 %; this value has the ratio of the thickness of the light-blocking pattern to the lens thickness (D'/D) as a parameter.

The relationship between D'/D and the aperture rate is shown in a graph in Figure 10.

It is seen from this graph that a screen with a bright image having an aperture rate of 90 % or greater is obtained in cases where (D'/D) is 10 % or less.

Furthermore, instead of laminating an ultraviolet-sensitive resin film 6 with the lenticular sheet, it would also be possible to coat said sheet with a liquid-form ultraviolet-sensitive resin which has similar characteristics.

Furthermore, the formation of a BS pattern by causing a powdered black toner to adhere only to the aforementioned adhesive portions instead of transferring a black transfer layer is also a modification which is within the scope of the present invention. However, in the case of a BS pattern formed by means of a toner, it is difficult to form stripes with sharp edges because of the shape of the toner particles; furthermore, the thickness of the BS pattern must be increased in order to obtain sufficient light-blocking properties.

Next, a light-diffusing film 14 supplied from a roll is laminated with the entire surface of the lenticular sheet including the BS pattern 23 by means of the aforementioned pair of laminating rolls 13, 13'.

For example, material sold under the trademark YS300, manufactured by SOMAR CORPORATION, etc., is used as the material of the light-diffusing film 14, and lamination can be performed at ordinary temperatures by subjecting the side of the lenticular sheet to which the film 14 is to be laminated to an adhesive treatment.

If the thickness of the above-mentioned lenticular sheet endowed with a light-diffusing function is 1 mm or so, the light from projector is seen brightly on the screen surface locally (in the direction, cylindrical lenses are installed with bar-form light) when observer watch the screen. On the other hand, if the abovementioned light-diffusing sheet is 0.5 mm or greater, the abovementioned phenomenon is cancelled. The abovementioned light-diffusing sheet can be obtained by mixing a light-diffusing material or medicine (inorganic substance) into a transparent resin sheet, the thickness is 0.5 mm greater, the control of the light-diffusing property becomes easily because the grain diameter of light-diffusing material is less restricted.

Finally, depending on the intended use of the sheet, a transparent resin film 16 endowed with an anti-electrification function or an anti-reflection function may be laminated with the lenticular sheet by means of the

aforementioned pair of laminating rolls 15, 15'.

A transparent resin film 16 with an anti-electrification function can be obtained by a method in which a nonionic, anionic or cationic surfactant is kneaded into a film, a method in which such a surfactant is mixed with a binder and applied to the surface of a film as a coating, or a method in which a substance endowed with conductivity, e.g., indium oxide doped with tin oxide, is vacuum-evaporated on the surface of a film so that a conductive coating film is formed, etc.

A transparent resin film 16 with an anti-reflection function can be obtained by mixing a powdered inorganic substance such as SiO_2, Al_2O_3 or $CaCO_3$, etc, with a binder to form a paint, coating the surface of a film with said paint, and laminating a non-glare film which has a roughened surface.

By laminating the abovementioned transparent resin film 16 with the lenticular sheet, it is possible to prevent the adhesion of dirt to the sheet due to static electricity, or to prevent glittering of the screen surface caused by the reflection of external light other than the projected image light, when the lenticular sheet is used as a screen. Furthermore, the lenticular sheet is endowed with rigidity, so that installation as a TV screen is facilitated.

A lenticular sheet with the structure illustrated in the sectional explanatory diagram shown in Figure 4 can be manufactured by the process described above.

Next, examples of lenticular sheets with other structures will be described.

Example 1

Example 1 relates to an example, wherein the diffusing layer is not a radiation curable resin.

An inorganic compound such as TiO_2 or SiO_2, etc., is dispersed in and mixed with a transparent resin (binder) to form a coating material; this coating material is then applied to a film consisting of a polyester resin, etc., thus forming a light-diffusing film.

The abovementioned film is then bonded to the flat surface on the non-lens side of a lenticular sheet in which lens parts 21 have been formed on one side of a transparent support 1 by means of a cured UV curable resin, thus forming a light-diffusing layer 14.

Alternatively, a light-diffusing layer may also be formed by applying the abovementioned coating material directly to the flat surface of the lenticular sheet (Figure 5(a)) instead of applying said coating material to a film.

Next, an ultraviolet-sensitive resin 6 is laminated on the surface of the abovementioned light-diffusing layer 14 (Figure 5(b)).

It is desirable that the ultraviolet-sensitive resin film 6 has characteristics which are such that the ultraviolet-exposed portions react to become non-adhesive, while the unexposed portions retain adhesive properties.

Non-adhesive parts and adhesive parts corresponding respectively to the focusing parts and non-focusing parts based on the focusing effect of the lenticular lenses are formed in the ultraviolet-sensitive resin film 6 by irradiation with ultraviolet light from an ultraviolet irradiation device (not shown in the figures).

Afterward, a black transfer layer is transferred only to the adhesive parts from a transfer sheet supplied from a roll; (not shown in the figures) by passing the lenticular sheet and said transfer sheet between a pair of laminating rolls (not shown in the figures), thus forming a BS pattern 23. In Figure 5, the focusing parts which constitute non-adhesive parts are indicated by shading, while the non-focusing parts which constitute adhesive parts are indicated as white parts (Figures 5(c) through 5(d)).

Ultraviolet light also reaches the photosensitive resin 6 via the light-diffusing layer 14; in this case, since the photosensitive parts spread out from the focusing parts as the amount of exposure (exposure intensity x exposure time), the width of the adhesive parts, i.e., the line width of the light-blocking pattern can be adjusted according to the amount of exposure.

Finally, a transparent resin film 16 endowed with an anti-electrification function or an anti-reflection function is laminated as in the case of Figure 4. In this case of this construction, the BS pattern 23 is exposed on the outermost surface of the lenticular sheet; accordingly, the transparent resin film 16 also acts to protect the BS pattern 23 which would otherwise easily fall off from the standpoint of handling.

Furthermore, the respective modifications described below are also within the scope of the present invention.

(1) A modification in which the photosensitive resin layer 6 is formed by coating the lenticular sheet with a liquid-form ultraviolet-sensitive resin with similar characteristics instead of using the aforementioned Chromalin film laminate.

(2) A modification in which the BS pattern is formed by causing a powdered black toner to adhere only to the aforementioned adhesive parts, instead of causing the transfer of a black transfer layer.

Example 2

Example 2 relates to an example, wherein the diffusing layer is a radiation curable resin.

In Figure 5, the light-diffusing layer 14 and the photosensitive resin layer 6 were formed as separate layers; however, it would also be possible to combine both of these layers into a single layer by endowing a photosensitive resin with a diffusing function.

Various types of photosensitive resins may be used; generally, however, resins which have acryloyl groups in the molecule are used. Specifically, oligomers such as epoxy acrylate, urethane acrylate, polyester acrylate or polyol acrylate oligomers, etc., or polymer-oligomer mixtures consisting of such polymers and methacrylic monomers which have monofunctional,

bifunctional or multifunctional groups (e.g., tetrahydrofurfuryl acrylate, polyethylene glycol diacrylate or trimethylolpropane triacrylate, etc.), are used.

Using the abovementioned photopolymers as binders, coating materials are formed by dispersing and mixing powdered inorganic compounds such as TiO_2, SiO_2, $CaCO_3$ or Al_2O_3, etc., as diffusing agents.

In addition, additives such as photopolymerization initiators, surfactants or defoaming agents, etc., may be added if necessary.

The abovementioned coating material is applied to the flat surface on the non-lens side of the lenticular sheet, in which lens parts 21 have been formed by means of a cured UV curable resin on one side of a transparent support 1, thus forming a photosensitive diffusing layer 25 (Figure 6(a)); afterward, a BS pattern 23 is formed in the same manner as described above (Figure 6(b)).

By using such a light-diffusing layer 25 which has photosensitivity and consists of a radiation curable resin in which a powdered inorganic compound is dispersed and mixed, it is possible to simplify the layer structure of the lenticular sheet.

The present invention provides a lenticular sheet in which cylindrical lens parts consisting of a radiation curable resin are formed on one side of a transparent support, and at least a light-diffusing layer and light-blocking stripes are formed on the flat surface located on the opposite side of said sheet. Cylindrical lens parts with a fine pitch of 0.3 mm or less can be obtained; furthermore, finely pitched light-blocking stripes can be accurately formed in the desired positions.

A projection screen constructed by combining the aforementioned lenticular sheet with a Fresnel lens sheet is ideally suited for viewing a liquid crystal projection TV with a high image definition.

Claims

1. A lenticular sheet comprising:

   a transparent support (1);
   a lens portion (21) comprising convex cylindrical lenses made of a cured radiation curable resin which are disposed side by side on one side of said transparent support (1);
   a stripe-form light-blocking pattern (23) disposed in positions corresponding to the non-focusing parts of the respective cylindrical lenses on the flat surface, which is located on the side of said support (1) opposite to said lens portion (21);
   and a light-diffusing layer (14) on top of said stripe-form light-blocking pattern (23).

2. A lenticular sheet comprising:

   a transparent support (1);
   a lens portion (21) comprising convex cylindrical lenses made of a cured radiation curable resin which are diposed side by side on one side of a transparent support (1);
   a light diffusing layer (14, 25) over the entire flat surface, which is located on the side of said support (1) opposite to said lens portion (21);
   and a stripe-form light-blocking pattern (23) disposed in positions corresponding to the non-focusing parts of the respective cylindrical lenses on top of said light-diffusing layer (14).

3. A lenticular sheet according to claim 1 or claim 2, wherein said lens portion (21) consists of convex cylindrical lenses having a pitch of 0.3 mm or less.

4. A lenticular sheet according to any of the preceding claims, wherein the aperture rate $(\theta-\theta')/\theta$ is at least 90 %, wherein

$$\theta = \tan^{-1}\{(P-P')/2D\}$$

$$\theta' = \tan^{-1}\{(P-P')/2(D+D')\}$$

   and P is the pitch of the convex cylindrical lenses, D is the thickness of the lenticular sheet, P' is the line width of the stripe-form light-blocking pattern and D' is the thickness of the light blocking pattern.

5. A lenticular sheet according to any of the preceding claims, wherein said light-blocking pattern (23) consists of a black transfer layer which is formed on adhesive parts of a positive photosensitive adhesive layer.

6. A lenticular sheet according to claim 2 or any of claims 3 to 5 when dependent on claim 2, wherein said light-diffusing layer (25) consists of a radiation curable resin in which a powdered inorganic compound is dispersed and mixed.

7. A lenticular sheet according to any of the preceding claims, further comprising a film with an anti-electrification function being laminated on the outermost surface of said sheet, on the side opposite to said lens portion (21).

8. A lenticular sheet according to any of claims 1 to 6, further comprising a film with an anti-reflection function being laminated on the outermost surface of said sheet, on the side opposite to said lens portion (21).

9. A method of fabricating the lenticular sheet according to claim 6, comprising the steps of:

   applying a radiation curable resin (25), in which a powdered inorganic compound has been dispersed and mixed as a coating to the flat surface of said transparent support (1) having said

lens portion (21) formed on one side and having a flat surface on the opposite side;
curing said radiation curable resin (25) by irradiation with radiation from the cylindrical lens side so that said radiation is focussed by said cylindrical lenses;
imparting a black color to the areas of the surface other than the cured areas.

10. A rear-projection screen comprising

the lenticular sheet according to any of claims 1 to 8 and a Fresnel lens sheet.

11. A rear-projection TV comprising the rear-projection screen according to claim 10.

FIG. 1

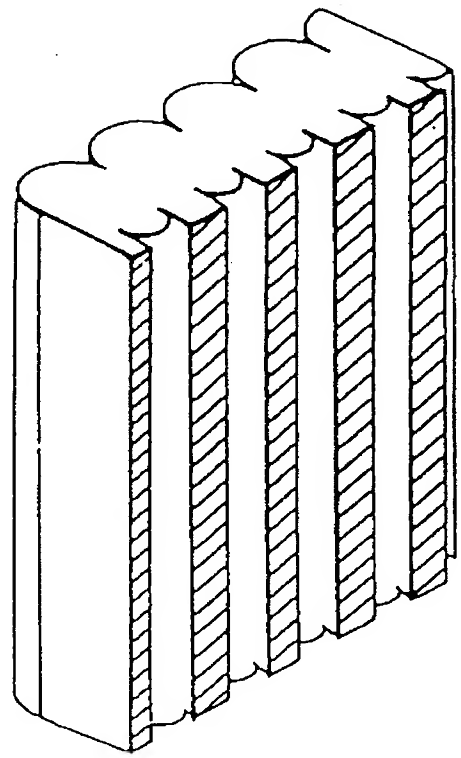
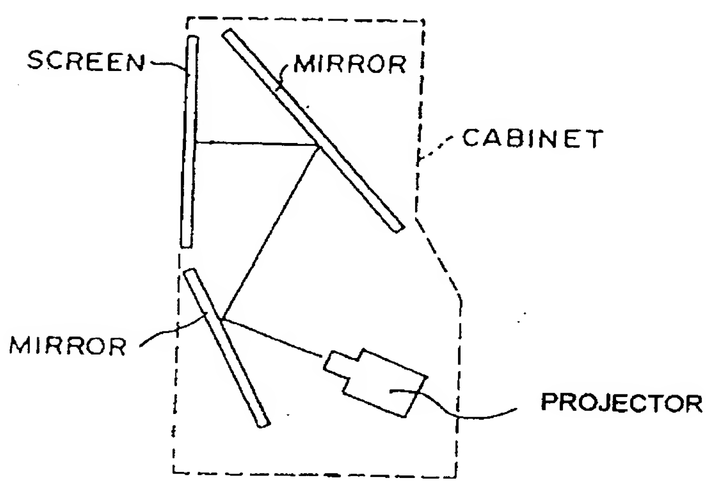


FIG. 2



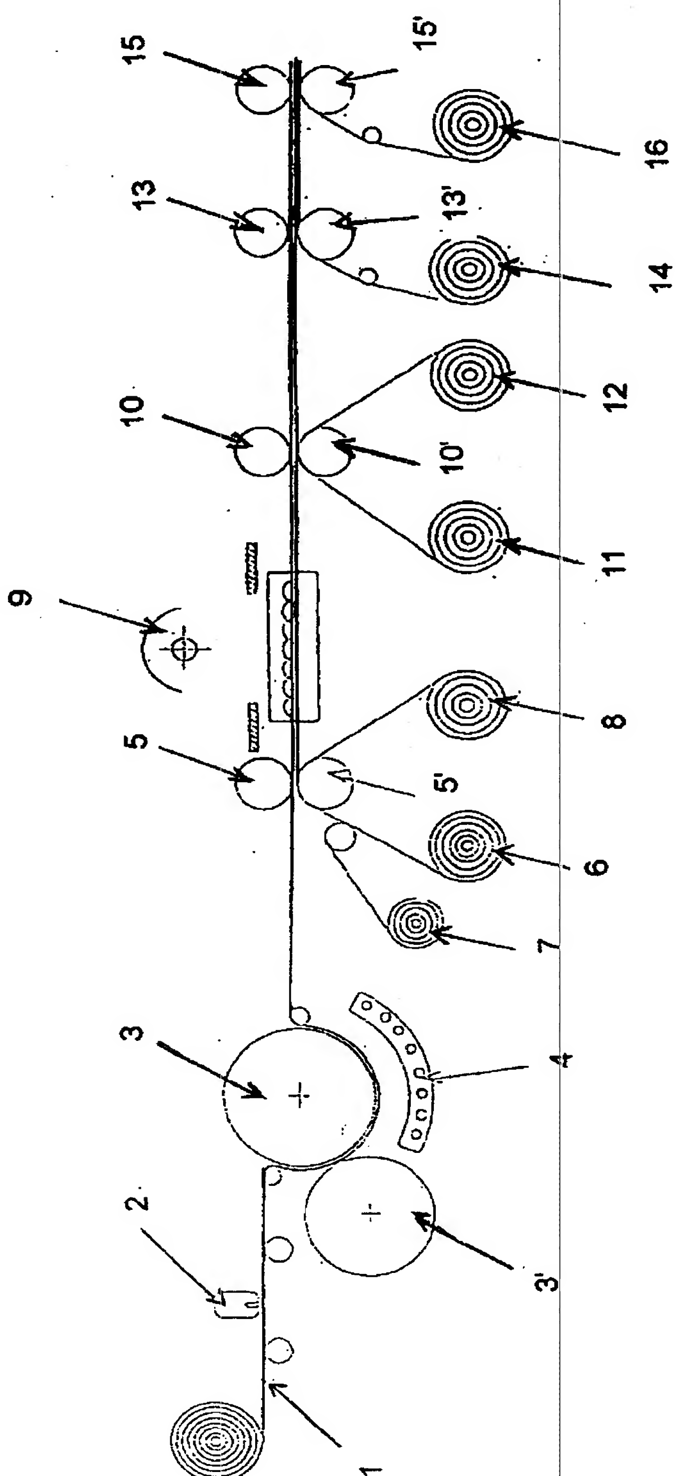


FIG. 3

FIG. 4

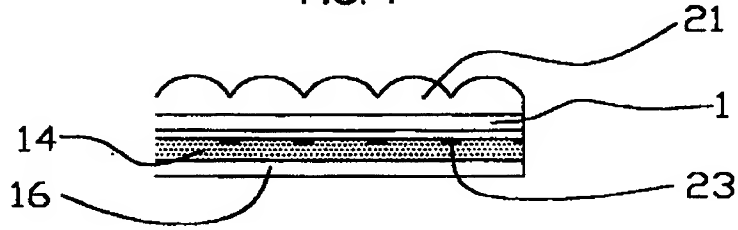


FIG. 5

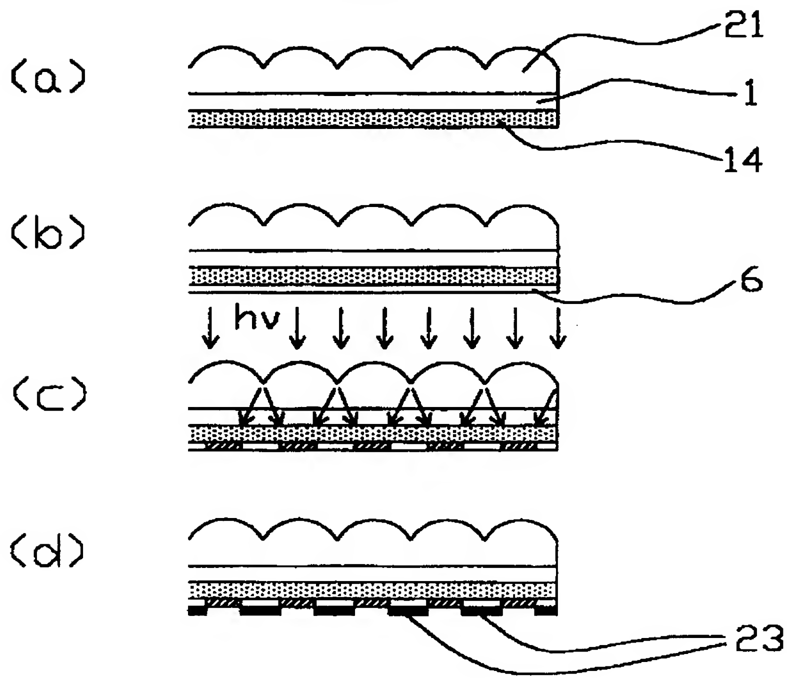


FIG. 6

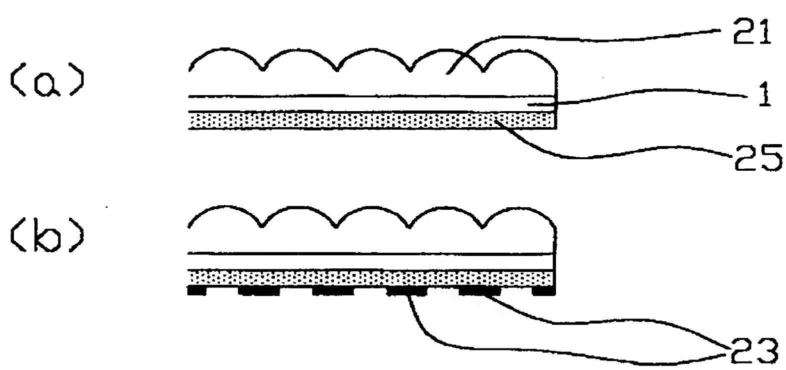


FIG. 7

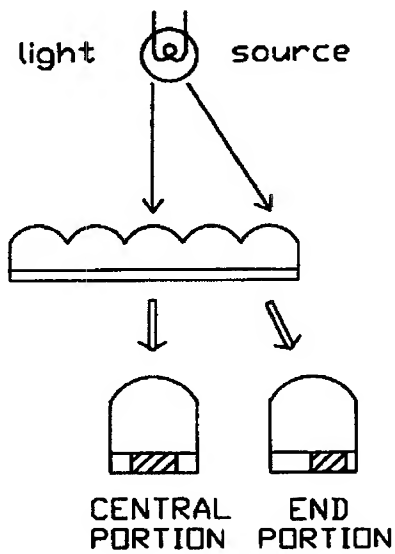

light
source
CENTRAL PORTION
END PORTION

FIG. 8

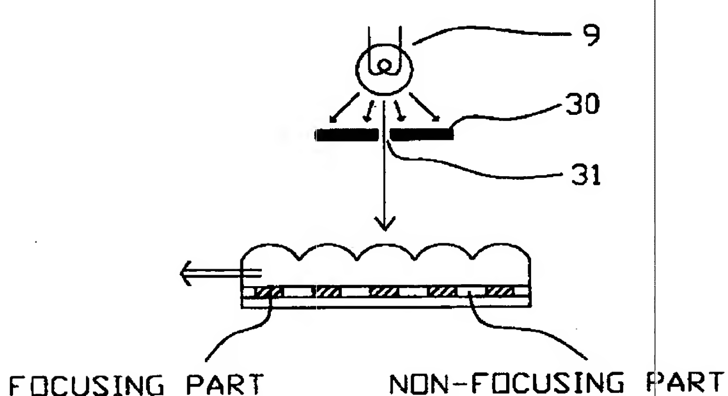
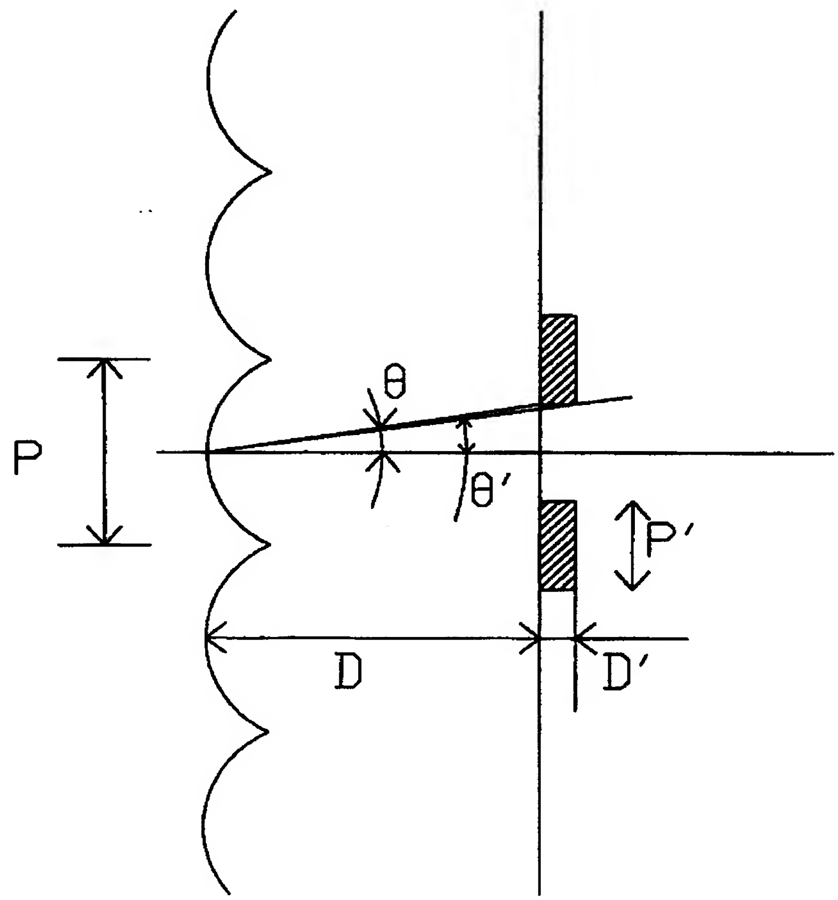
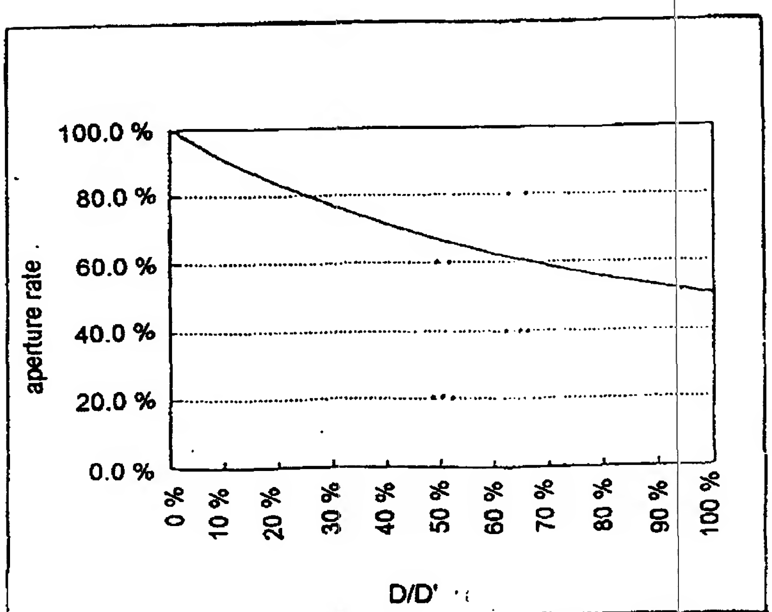

9
30
31
FOCUSING PART
NON-FOCUSING PART

FIG. 9



$$\text{aperture rate} = \frac{\theta - \theta'}{\theta} \geqq 90\%$$

FIG. 10


100.0 %
80.0 %
60.0 %
40.0 %
20.0 %
0.0 %
aperture rate
0 %
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
100 %
D/D'

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 7082

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 4 165 154 A (TAKAHASHI YOSHIMASA) 21 August 1979 * column 3, line 29 - column 5, line 9; figures 7-10 *	1-3,5,8, 10,11	G03B21/62
Y	US 4 666 248 A (VAN DE VEN JOHANNES) 19 May 1987 * column 4, line 25 - column 5, line 2; claims 1,6,7; figures 1-3B *	1-3,5,8, 10,11	
A	US 4 408 837 A (KOZAKI SYUICHI ET AL) 11 October 1983 * column 1, line 1 - line 36; claims 1,2 *	7,8	
A	PATENT ABSTRACTS OF JAPAN vol. 95, no. 009, 31 October 1995 & JP 07 159902 A (MITSUBISHI RAYON CO LTD), 23 June 1995, * abstract *	1,2,9-11	
A,D	PATENT ABSTRACTS OF JAPAN vol. 012, no. 381 (M-752), 12 October 1988 & JP 63 134227 A (DAINIPPON PRINTING CO LTD), 6 June 1988, * abstract *	1,2,9-11	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G03B G02F
A	US 5 191 472 A (KUREMATSU KATSUMI ET AL) 2 March 1993 * the whole document *	5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	4 December 1996	Manntz, W

CATEGORY OF CITED DOCUMENTS

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